[Proc. Roy. Soc. Victoria, 56 (N.S.), Pt. II., 1945.]

Art. X.—*Mesozoic Fossils from the Central Highlands of New Guinea.*

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(Published by permission of the Directors of Australasian Petroleum Company, Melbourne.)

[Read 9th December, 1943; issued separately 30th June, 1945.]

Abstract.

Upper Jurassic and middle Cretaceous mollusca from Central New Guinea are described, including genera and species known from the Upper Jurassic of north-western India and of the East Indies (*Buchia-Belemnopsis* fauna), from the Upper Albian and Cenomanian of southern India and from the Aptian-Albian of Australia. Lists of foraminifera are given and the stratigraphic position of fossiliferous Mesozoic sediments of Papua and New Guinea is discussed.

Introduction.

The samples of fossiliferous rocks and fossils described in the following communication were collected in 1938-1940 by geological field parties engaged in reconnaissance surveys on behalf of Island Exploration Company and Australasian Petroleum Company. These parties were led by Dr. W. D. Chawner, Mr. N. Osborne, and Dr. S. W. Carey. A small number of fossils collected in 1939 by Mr. L. C. Noakes, then Assistant Government Geologist of the Territory of New Guinea, have also been studied.

For detailed accounts of field observations in the Mesozoic sediments of Papua, including localities at which rock samples and fossils were collected, reference should be made to publications by N. Osborne (1944), and S. W. Carey (1944). The author has discussed recently general questions of stratigraphic correlation in a wider area (Glaessner, 1943).

The fossils described in the following account were taken from the Kuabgen group (Upper Jurassic) and the Feing group (Albian-Cenomanian) which form a sequence of strata 7,500 feet thick in the Fly River headwaters in Western Papua, from the two lower divisions of the "Wahgi Series" (Jurassic, Aptian-Albian) of the Chimbu-Mt. Hagen area, Territory of New Guinea, and from the Lower Cretaceous Purari formation on the Middle Purari River, Papua (see map). Type specimens have been deposited in the collection of the Geology Department of Melbourne University, and representative fossils and rock samples will be forwarded to the Commonwealth Geological Collection, Canberra.

The writer wishes to express his gratitude to Mr. N. Osborne and Dr. S. W. Carey for valuable material and useful information placed at his disposal, to Dr. F. W. Whitehouse for the generic determination of one of the fossils, to Dr. N. H. Fisher, former Government Geologist, Territory of New Guinea, for permission to quote from an unpublished report by L. C. Noakes, and to the Directors of the Island Exploration Company and Australasian Petroleum Company for permission to publish this contribution.

Jurassic Fossils.

FORAMINIFERA.

A small number of foraminiferal tests representing the genera "*Cristellaria*", *Nodosaria*, *Dentalina* and *Epistomina* occurs in the dark shales of the Kuabgen group of the Upper Fly River (samples 215, 213). These are generally the most common genera of foraminifera occurring in Upper Jurassic clays and shales.

MOLLUSCA.

1. **Grammatodon (Indogrammatodon) virgatus** (J. de C. Sowerby).

(Pl. VI., figs. 1*a-b*.)

Cucullaea virgata J. de C. Sowerby, 1840. Trans. Geol. Soc. (2), vol. 5, pl. 22, figs. 1-2.

Grammatodon (*Indogrammatodon*) *virgatus*, L. R. Cox, 1937. Proc. Malacol. Soc. London, vol. 22, p. 195, pl. 15, figs 8, 9.

Grammatodon (*Indogrammatodon*) *virgatus*, L. R. Cox, 1940. Pal. Indica., ser. 9, vol. 3, pt. 3, p. 74, pl 2, figs. 22-30.

Material.—A single specimen, almost complete, both valves preserved but distorted by dorso-ventral compression.

Occurrence.—Black shale, lower part of Kuabgen group, about 3,300 feet below the top (sample 252).

Description.—The characters of this specimen agree with *G. virgatus* as redescribed by Cox. The main distinguishing features of the subgenus *Indogrammatodon*, the inequilateral shape and the difference in ornamentation of the two valves are clearly visible. The radial ribs in the left valve are stronger and more widely spaced. The umbones are placed at about the anterior two-fifths of the length. About 18-20 ribs are visible in the left valve anterior to the rounded carina, and about 16 are distinguishable on the anterior half of the right valve, with a few finer riblets intercalated between the 8th to 12th ribs. About 12 less distinct postero-ventral ribs are also recognizable. The posterior area of the right valve bears two or three radial threads.

The large number of radial ribs, their shape and distribution and other well preserved characters of ornamentation agree with *G.* (*I.*) *virgatus*, rather than with the similar *G.* (*I.*) *egertonianus* (Stoliczka). As far as distortion does not interfere with measurements, they are in agreement with *virgatus*, particularly the position of the umbones. *G.* (*I.*) *egertonianus* is more inequilateral.

Measurements.—Length of hinge margin 33 mm., umbo about 13-14 mm. from the anterior end of the hinge margin; height uncertain, probably more than 15 and less than 20 mm.

Age.—According to L. R. Cox, *G.* (*I.*) *virgatus* ranges from the *macrocephalus*-beds of the Lower Chari of Kachh, north-western India (Upper Bathonian or Lower Callovian) through the Middle Chari (Callovian) and the *athleta*-beds to the lower Dhosa Oolite of Lower Oxfordian (Upper Divesian) age.

2. **Meleagrinella braamburiensis** (Phillips).

(Pl. VI., figs. 2-4.)

Avicula braamburiensis nom. nud., J. de C. Sowerby, 1829, in: Murchison. Trans. Geol. Soc., (2), vol. 2, p. 323.

Avicula braamburiensis, Phillips, 1829. Ill. Geol. Yorkshire, p. 140.

Pseudomonotis braamburiensis, Douglas and Arkell, 1932. Quart. Journ. Geol. Soc., vol. 88, p. 163, pl. 12, figs. 5, 6.

?*Aucella* sp., Wandel, 1936, N. Jahrb. f. Min., Beil.-Bd. 71, (B), p. 461, fig. 1*a-c*.

Material.—Numerous closely-packed small single valves, about 24 examined.

Occurrence.—Black sandy shale, with *Belemnopsis* cf. *indica*, lower part of Kuabgen group (sample 219). About 40 feet below the *Buchia*-bed.

Description.—" Left valve moderately flattened, much less inflated than in *Pseudomonotis echinata* (Sow.), ornamented with some 25-30 fine thread-like ribs, which are faintly knotted at long intervals where crossed by some of the more prominent of the indistinct growth lines. The ribs are separated by wide, flat sulci, at least three to four times as wide as the ribs, and between every pair is a still finer secondary rib. The ornament is essentially radial, very little concentric element entering into it. Umbo small, much less tumid than in *P. echinata*, salient about 1½ mm. dorsal to the hinge-line.

Right valve nearly flat, but with surface rising slightly towards the umbo, which is not salient dorsal to the hinge line. Ornament as in the left valve, but more reticulate, owing to the concentric growth lines being more visible. Auricles small, the ribs covering them in both valves." (Douglas and Arkell).

Measurements.—Height about 16-17 mm., length about 9-14 mm. (left valves).

The available material from the Jurassic of Central New Guinea agrees well with *M. braamburiensis* rather than with the typical wide-ranging *M. echinata,* mainly in the characters of the left valve which is less inflated, with "essentially radial" ornamentation. The right vales are smooth or show only faint traces of radial threads and weak concentric growth lines. The new specimens also resemble a form considered by Wandel as an "*Aucella*" belonging to the group of *A. malayomaorica* Krumbeck. The strongly-developed angular posterior auricle, the straight hinge margin and the deep, narrow byssal notch agree with *Echinotis* and distinguish these shells from *Buchia.* The concentric ornament is much reduced, as in *M. braamburiensis.*

Measurements.—Height about 16-17 mm., length about 9-14 mm. (left valves).

Age.—*M. braamburiensis* was described from the Lower Oxfordian of England. Wandel's "*Aucella*" comes from the middle and upper part of the Lower Oxfordian of Misol (Demú limestone and Lilintá marly limestone). L. R. Cox (1940) found the majority of his specimens of *M. echinata* from the Bathonian of Kachh closely resembling *M. braamburiensis.* He states that the stratigraphic difference which exists in England between the typical *M. echinata* (Bathonian) and *M. braamburiensis* was not observed in the Indian material.

3. **Buchia malayomaorica** (Krumbeck).

(Pl. VI., figs. 5, 6, 7*a-b.*)

Aucella plicata (non Zittel), G. Boehm, 1911, N. Jahrb. f. Min. (i), p. 13, pl. 2, figs. 1-4.

Aucella malayomaarica Krumbeck, 1923, Pal. v. Timor, Lfg. 12, Abh. 20, p. 65, pl. 2, figs. 2-12, 17; pl. 6, fig. 13.

Aucella plicata (non Zittel), Trechman, 1923. Quart. Journ. Geol. Soc., vol. 79, p. 266, pl. 17, figs. 4-8.

Pseudomanotis sp., Broili, 1924. Wet. Mededeel., vol. 1, p. 10, figs. 10, 11.

Aucella boehmi Marwick, 1926. Trans. N.Z. Inst., vol. 56, p. 305, pl. 71, figs. 10-13.

Aucella plicata (non Zittel), Kruizinga, 1926. Jaarb. Mijnw., vol. 54, Verh., pt. 1, p. 17.

Buchia boehmi, Marwick, 1934. Proc. Fifth Pacif. Sci. Congr., p. 949.

Aucella malayomaorica, Krumbeck, 1934. N. Jahrb. f. Min., Beil.-Bd. 71, (B), p. 446ff., 462.

Aucella malayomaorica, Wandel, 1936. N. Jahrb. f. Min., Beil.-Bd. 75, (B), p. 456, pl. 15, figs. 5, 6; pl. 17, figs. 1-11.

Buchia malayomaorica, Teichert, 1940. Journ. Roy. Soc. W. Austr., vol. 26, p. 109.

Buchia malayomaorica, Glaessner, 1943. Proc. Roy. Soc. Vict., vol. 55, pt. 1, p. 45.

Material.—Numerous right and left valves, about 24 specimens examined.

Occurrence.—Black shale with *Inoceramus* and *Belemnopsis gerardi,* top of lower division of Kuabgen group (sample 215), locally forming a shell breccia. Also in dark-red to chocolate-coloured shale, about 2,700 feet above base of Chimbu-Wahgi section (Lower Wahgi valley, Noakes coll., sample 57) and in similar stratigraphic position in green calcareous shale 18 miles east of Mt. Hagen aerodrome (Noakes coll., sample 78). *Buchia malayomaorica* has been described from Timor, Rotti, Jamdena, Ceram, Boeroe, the Soela Islands, Misol, Boeton, East Celebes, Western New Guinea (Itebere R., Kamoendan River headwaters, Amberbaken district) and New Zealand (Locality 1193, West of Waikiekie Stream, Kawhia Harbour).

Description.—This species was fully described by Krumbeck (1923), Marwick (1926), and Wandel (1936). The new specimens agree with these descriptions. The outline of the shell shows little variation. The anterior and posterior margins of the valves are nearly parallel ("forma typica"). The approximately rectangular outline in this species differs markedly from the oblique shape of typical representatives of the genus. The surface ornamentation is variable. Krumbeck observed this variability and stated that almost all right valves showed radial as well as concentric ornamentation while only rare left valves had distinct radial ribs. In the present material variability of the radial ribs affects both valves about equally.

Measurements.—Adult valves are about 30 mm. high and about 20 mm. long, but the ratio is variable.

Age.—Upper part of Lower Oxfordian or lower part of Upper Oxfordian. (Approximately zone of *Cardioceras cordatum* ?).

4. **Inoceramus** sp.

Inoceramus occurs in at least two horizons in the Kuabgen group (samples 215, 213) but the available material is not sufficiently well preserved to permit specific identification. Fragments of large shells resemble *I. haasti* Hochstetter as well as *I. subhaasti* Wandel and *I. galoi* G. Boehm. Fragments of *Inoceramus* occur with *Buchia malayomaorica* in the Chimbu-Wahgi section (Noakes' sample 57).

5. **Belemnopsis gerardi** (Oppel).

(Pl. VI., figs. 8, 9*a-b*.)

Belemnites gerardi, Oppel, 1865. Pal. Mitt. a.d. Mus. d. Bayer. Staates, pl. 88, fig. 1.

Belemnites gerardi, Uhlig, 1910. Pal. Indica, ser. 15, vol. 4, p. 386, pl. 93.

Belemnopsis gerardi, Kruizinga, 1921. Jaarb. v. h. Mijnw., vol. 49, Verh. pt. 2, p. 163, pl. 1, fig. 1, 3.

Belemnites gerardi, Broili, 1924. Wet. Mededeel, vol. 1, p. 8, pl. 2, fig. 9.

Belemnopsis gerardi, Stolley, 1929. Pal. v. Timor, Lfg. 16, Abh. 29, p. 151, pl. 248, figs. 16-32, pl. 249, figs. 1-3.

Belemnopsis gerardi, Spath, 1933. Pal. Indica, n.s., vol. 9, Mem. 2, pt. vi., p. 660ff.

Belemnopsis gerardi, Spath, 1939. Pal. Indica, n.s., vol. 25, Mem. 1, pt. iii., p. 135.

Material.—Four well-preserved specimens and about 20 fragments.

Occurrence.—Abundant in black shale with *Buchia malayomaorica* and *Inoceramus*, top of lower division of Kuabgen group (sample 215), also in upper division, about 1,100 feet higher (sample 213).

Remarks.—This is a controversial species. Without detailed examination of large numbers of well-preserved specimens and comparison with the holotypes of several similar named species which are evidently variable and overlap morphologically, nothing useful can be added to the controversy about the synonymy of this group. The new specimens agree with some of those figured by Uhlig from the Spiti shales (l.c. pl. 93, figs. 7, 9), by Kruizinga from Taliaboe and Mangoeli, Soela Islands, and by Stolley from Timor. Broili figured a specimen from Western New Guinea (Kamoendan River headwaters) as *B. gerardi*. While resembling the present material in its general character it differs in shape, having its greatest width below the middle of the length of the guard, as in *B. taliabutica* (G. Boehm). *B. alfurica* G. Boehm and a similar form described by Teichert from Broome, Western Australia, as *B. cf. alfurica* have a deeper ventral groove, a more circular transverse section, slender shape and narrower alveolar part.

Age.—Notwithstanding the controversy about the synonymy of *B. gerardi* and the age of its holotype, this fossil is a valuable stratigraphic marker for the Oxfordian in the eastern part of the Sunda archipelago. Abundant occurrence like that observed in the *Buchia-Belemnopsis* bed of the Kuabgen group is recorded from the Wai Galo beds of the Soela Islands. This important fossiliferous horizon is assigned by Spath to the *cordatum*-zone of the Oxfordian and its stratigraphic position is close to that of the Belemnite beds at the base of the Spiti shales in the Himalaya. In his recent discussion of *B. gerardi*, Spath came to the conclusion that its range is Upper Jurassic (and possible Lower Neocomian).

6. **Belemnopsis** cf. **indica** Kruizinga.

cf. *Belemnopsis indica*, Kruizinga, 1921. Jaarb. Mijnw., vol. 49, Verh. pt. 2, p. 171, pl. 3, fig. 1-3.

cf. *Belemnopsis indica*, Stolley, 1929. Pal. v. Timor, Lfg. 16, Abh. 29, p. 165, pl. 250, figs. 7-10.

cf. *Belemnopsis indica*, Kruizinga, 1931. Leidsche Geol. Mededeel., vol. 5, p. 369, 377.

cf. *Belemnopsis indica*, Stolley, 1935. N. Jahrb. f. Min., Beil.-Bd. 73, Abt. B. p. 50.

Material.—Two fragmentary rostra, apical portion not preserved.

Occurrence.—Sandy shale, with *Meleagrinella braamburiensis*, lower part of Kuabgen group (sample 219). About 40 feet below the bed with *Buchia* and *Belemnopsis gerardi*.

Remarks.—This species is characterized, according to Kruizinga, by the shape of its rostrum. The greatest width is in the middle, and the dorso-ventral diameter is 20 per cent. shorter than the transverse diameter. These features are clearly recognizable in the two available fragments which are quite unlike any of the numerous fragments of B. gerardi from a slightly higher horizon. They resemble however *B. calloviensis* (Oppel) as figured by Spath (1927, p. 6, pl. 1, fig. 7).

Age.—*B. indica* is known from the Oxfordian of Taliaboe and Rotti and the "Lower Oxfordian" of Boeroe, Mangoli and Misol.

Cretaceous Fossils.

FORAMINIFERA.

Feing group.—A rich and varied foraminiferal fauna occurs in the argillaceous rocks of the Feing group. Only preliminary determinations are at present available. They indicate clearly late Lower Cretaceous to early Upper Cretaceous age.

The lowest fossiliferous sample (210) contains the following fauna:—

Trochamminoides sp.
"Cristellaria" sp.
Marginulina spp.
Nodosaria sp.
Lagena sp.
Pleurostomella sp.
Gyroidina nitida Reuss.
Anomalina sp.
Globigerina infracretacea Glaessner.

The occurrence of *Pleurostomella* is important as this genus is not known in earlier than late Albian beds. The assemblage does not contain any distinctive Upper Cretaceous elements.

It is followed by a rich fauna occurring in numerous samples from the higher part of the Feing group. This fauna includes:—

Rhizammina sp.
Ammodiscus sp.
Haplophragmoides sp.
Trochamminoides sp.
Ammobaculites sp.
Textularia washitensis Carsey.
Textularia rioensis Carsey.
Dorothia filiformis (Berthelin).
Dentalina communis d'Orbigny.
Nodosaria affinis Reuss.
Nodosaria obscura Reuss.
Nodosaria soluta Reuss.
Tristix excavata (Reuss).
Lenticulina sp.
Marginulina sp.
Saracenaria sp.
Globulina lacrima Reuss.
Buliminella sp.
Bulimina reussi Morrow.
Pleurostomella subnodosa Reuss.
Gyroidina nitida Reuss.
Anomalina spp.
Globigerina infracretacea Glaessner.
Globigerina spp.
Globotruncana aff. *appenninica* O. Renz.

The lowest occurrence of this fauna is reported from a horizon 1,300 feet above the base of the Feing group (sample 224). The composition of the assemblage suggests Cenomanian age. Some of its species, particularly *Textularia washitensis* occur also in the shales with Cenomanian ammonites at Mingenda in the Wahgi valley and in "Stage 3" of the Chimbu-Wahgi section (see below p. 166). *Globotruncana* aff. *appenninica*, a single-keeled species of this typical Upper Cretaceous genus, with inflated chambers, appears to be a world-wide marker for Cenomanian. It has not been recorded yet from elsewhere in New Guinea.

2. Purari formation.—The foraminiferal fauna of the Purari formation is generally rather poorly preserved. It appears to be uniformly distributed throughout the sections exposed in Paw Creek (see Carey, 1944). The following preliminary determinations have been made:—

Rhizammina sp. (common).
Ammodiscus sp.
Haplophrammoides sp. (common).
Dorothia gradata (Berthelin) (common).
Lenticulina gaultina (Berthelin) (frequent).
Lenticulina sp.
Astacolus sp.
Vaginulina sp.
Planularia sp.
Marginulina spp.
Nodosaria sp.
Lagena apiculata Reuss.
Globulina sp.
Buliminella sp.
Gyroidina aff. *nitida* Reuss.
Epistomina sp.

The general composition of this fauna agrees with assemblages found in the upper part of the Lower Cretaceous (Aptian or Albian). It resembles the foraminiferal fauna of the lower part of the Feing group; *Pleurostomella* and *Globigerina* are however absent from the Purari fauna.

MOLLUSCA.

The Mollusca of the Feing Group.

Pseudavicula sp.

Material.—Numerous valves (about 20-30), both right and left, mostly preserved as internal and external casts, with fragments of the shell attached.

Occurrence.—Dark shale of the Feing group (samples 210, 239), about 500 feet above base, with *Parahibolites blanfordi.*

Description.—Shell small, suborbicular, inequilateral, compressed, test very thin, often wrinkled by rock pressure. Umbo small, very little projecting, sub-central in relation to the greatest length of the valve. Dorsal margins straight, antero-dorsal margin long, slightly convex, forming a blunt angle with the broadly rounded ventral and posterior margin. Posterior auricle large, with a distinct dorsal rim, posterior margin convex. Surface covered with numerous blunt radial ribs, unequal in width, with narrow smooth interspaces.

The large size of the anterior portion of the shell appears to be a distinctive feature of these fossils but the available material is not well enough preserved to permit a more detailed description and identification.

Age.—Upper Albian.

Inoceramus sp.

Fragments of large shells representing an undetermined species of *Inoceramus* occur in the type area of the Feing group (samples 212, 239, 209) and also in the Palmer River area, 20 miles east-south-east (Chawner coll., samples 14, 121).

Turrilites aff. **costatus** Lamarck.

Material.—A distorted and partly crushed fragment of a single whorl.

Occurrence.—Feing group, basal part of Narin formation (Chawner coll., Palmer River, sample 115).

Remarks.—This fragmentary specimen resembles *T. costatus* Lamarck and also *T. acutus* Passy which according to Spath is connected with Lamarck's species by innumerable passage forms. *T. costatus* is known from the Cenomanian of Europe, North Africa, Palestine, Zululand, Madagascar and Southern India (Middle Utatur group). *T. acutus* is known from the Cenomanian of France, Northern Germany, North Africa and Natal and the "Vraconnian" of Mexico.

Parahibolites blanfordi (Spengler).

(Pl. VI., figs. 10*a-c*.)

Belemnites fibula (pars), Blanford, 1861, The foss. Cephalop. of the Cret. rocks of S. India. Pal. Indica., ser. 1, p. 3, pl. 1, figs. 14, 16-19, 24-34, 41; pl. 2, figs. 5, 6 (non *B. fibula* Forbes).

Belemnites n.sp., Kossmat, 1897. Rec. Geol. Survey of India, vol. 30, pt. 2, p. 87.

Pseudobelus blanfordi Spengler, 1910. Beitr. z. Pal. u. Geol. Oesterr.-Ung. u.d. Orients, vol. 23, H.3, p. 155, pl. 12, fig. 6, pl. 14, fig. 6.

Parahibolites blanfordi, Bülow-Trummer, 1920. Fossilium Catalogus i., pt. 11, p. 164.

Material.—A single well-preserved rostrum.

Occurrence.—Dark shale of Feing group, 500 feet above base, with *Pseudavicula* sp. and smaller foraminifera (sample 210).

Description.—"Guard elongated, compressed, columnar or lanceolate, acutely pointed behind on the frontal aspect. Section oval or oblong. Ventral surface evenly rounded with a very short furrow at the anterior extremity. Sides more or less flattened, having in some specimens a shallow sulcation, most distinct in front; marked very distinctly with a double vascular impression, which generally extends the whole length of the guard. The alveolar cavity very acute, and extending in all the specimens examined, considerably more than half the length of the guard. It is somewhat eccentric, particularly in very compressed specimens." (Blanford).

Remarks.—The laterally compressed shape, short ventral groove, and well-developed straight lateral lines over the whole length of the Feing specimen agree well with the species described by Blanford as *B. fibula.*

Age.—This species is known only from the Lower Utatur group of southern India, zone of *Stoliczkaia dispar,* Upper Albian ("Vraconnian").

The Mollusca of the Purari Formation.

A rich fauna of mollusca was obtained by Carey in the area occupied by the sediments of the Purari formation. The majority of samples taken from outcrops contain only smaller foraminifera and other microfossils (holothurian plates, ophiuran vertebral ossicles, ostracodes) and undeterminable echinoid remains. One bed in the upper part of the exposed section is rich in *Exogyra* aff. *couloni* and contains also *Ostrea* sp. and a small number of undetermined lamellibranchs and gastropods. Numerous pebbles and boulders of a blue, hard sandy limestone or calcareous sandstone collected in the creeks in this area are extremely rich in mollusca. This "molluscan bed" has not been seen in situ in the type area of the Purari formation (Paw Creek). Carey (1944) states that "the horizon of the molluscan material cannot be very different from that of the *Exogyra* bed."

Owing to limitations of available time and facilities the present writer has not yet been able to carry out a complete study of this rich fauna. A list of a few distinctive forms follows, and the most abundantly occurring species among them is described, together with the *Exogyra* and a belemnite, a perfect specimen of which was found in a loose block of sandstone.

The fauna includes *Lingula* cf. *subovalis* Davidson, *Trigonia* sp., *Cardium* sp. *Ptychomya* sp., *Pseudavicula papyracea* Etheridge, *Ostrea* sp., *Mytilus* sp., *Nerinea* sp., *Alaria* (*Anchura*) cf. *wilkinsoni* Etheridge, *?Praestriaptychus* sp., *Tetrabelus macgregori* n. sp.

1. **Pseudavicula papyracea** R. Ethridge, jun.

(Pl. VI., fig. 11.)

"Undetermined bivalve", R. Etheridge, jun., 1892. Geol. Pal. Queensland. p. 482, pl. 21, fig. 14.

Pseudavicula papyracea, R. Etheridge, jun., 1907. Rec. Austral. Mus., vol. 6, No. 5, p. 319.

Material.—Large numbers of more or less well preserved specimens.

Occurrence.—Abundant in calcareous sandstones rich in mollusca, Purari formation, Paw Creek, and Wabo Creek, Middle Purari valley (not found in situ). Similar forms occur also in "Stage 2" of the Chimbu-Wahgi section, Lower Wahgi valley (Noakes coll., sample 30).

Description.—"Shell suborbicular, delicate and fragile, compressed, posteriorly, alate, test very thin, papyraceous. Left valve convex in the umbonal region, with a sharply-pointed rather elevated umbo. Right valve more depressed than the left and the umbo inconspicuous. Dorsal margins on both sides straight, those anterior to the umbo obliquely inclined, those on the posterior straight; anterior ends small, the margins rounded; posterior alations small, flat, the margins rectangular. Sculpture of microscopic concentric lines." (Etheridge 1907.)

Measurements.—In the majority of examined specimens the height varies between 15 and 30 mm.

Remarks.—The characters of the most abundant lamellibranch of the Purari molluscan fauna appear to agree well with Etheridge's description. The left valve, not figured by Etheridge, resembles his second "undetermined bivalve" (l.c. 1892, pl. 21, fig. 16) although as stated by this author, the umbo is further removed from the anterior margin in the present species. In some specimens the concentric growth lines are fairly well marked. The present writer has been unable to compare his material with Etheridge's type specimens.

2. **Exogyra** aff. **couloni** (Defrance).

Material.—Numerous specimens, mostly casts with fragments of the shell preserved. Left valve attached to various molluscan shells.

Occurrence.—A distinctive calcareous "*Exogyra*-bed," about 10 feet thick, in the upper part of the Purari formation; Paw Creek area, middle Purari valley. (Samples 130-139.)

Remarks.—The present specimens, although abundant, are rather poorly preserved. They agree in general with the description of *E. couloni* given by H. Woods ("*E. sinuata* Sowerby," H. Woods, Palaeontogr. Soc, vol. 66, 1913, p. 395, pl. 61, fig. 13, text figures 194-214). The only noticeable difference is the absence of any concavity of the posterior margin of the shell. It is generally straight. None of the specimens seen is nearly as large as the largest European representatives of the species (average length about 5 cm.).

Age.—*E. couloni* is a common fossil of the Lower Cretaceous. An *E.* cf. *couloni* was reported by Piroutet from the Lower Cretaceous (Moindou) of New Caledonia.

3. **Tetrabelus macgregori** n. sp.

(Pl. VI., figs. 12*a-b*.)

?Belemnites sp., R. Etheridge, jun., 1902. Mem. Geol. Survey N.S.W., Palaeont. Nr. 11, p. 46, pl. 9, figs. 3-5.

?*Tetrabelus* sp., F. W. Whitehouse, 1924. Geol. Mag., vol. 59, p. 413ff.

Material.—One large well-preserved rostrum, one small rostrum of similar type, and several fragments which are enclosed in hard rock.

Occurrence.—Tuffaceous and calcareous sandstones of the Purari formation, Paw Creek, Middle Purari valley. Holotype from sample 186, Paw Creek, not in situ. Also in boulders of molluscan sandstone from Paw Creek (samples 65, 107, 109) and Wabo Creek (sample 20).

Description.—The holotype of this species was examined by Dr. F. W. Whitehouse who recognized it as a new species of *Tetrabelus*. Whitehouse (l.c., 1924) established this genus for "clavate belemnites provided with dorso-lateral grooves and lateral lines, having, in addition, independent ventro-lateral grooves. Alveolus normal." In the new species the rostrum is strongly constricted in the post alveolar region and dorso-ventrally compressed, particularly where it expands again to its greatest width. Dorso-lateral grooves well developed, prominent and deep, passing at about one-third of the length of the rostrum into the less conspicuous lateral lines, the connection being not straight but ventrally curved. The lateral lines continue nearly to the apex. Ventro-lateral grooves faintly developed in the alveolar region.

Measurements.—Length 100 mm., greatest width 13 mm., dorso-ventral diameter between alveolar region and zone of greatest width 9.3 to 9.6 mm., minimum width in alveolar region 9.8 mm.

Remarks.—The writer was unable to compare the new form with the original of Etheridge's unnamed belemnite from the Aptian of New South Wales. The two specimens appear to be very similar in size and shape but Etheridge's form contracts more rapidly toward the apex. According to Whitehouse it "shows a very long ventro-lateral groove converging towards the dorso-lateral near the apex". This is not the case in the Purari specimens. Whitehouse also states that "from the figure given by Etheridge the two grooves are of almost equal strength, the dorso-lateral however being possibly a little more prominent. In *T. klcini* all grooves are of equal impress, while in *T. seclusus* the ventro-lateral is much more distinct than the dorso-lateral." From this description it appears that the new species is different from all known representatives of the genus. If Whitehouse's view of a "morphological progression" from *Dimitobelus*, without independent ventro-lateral grooves, through the known species of *Tetrabelus* is accepted, then the new species should be regarded as the most primitive form.

This species is named after Sir William MacGregor, explorer and administrator of Papua, who discovered the Cretaceous rocks on the Purari in 1894.

Stratigraphic Conclusions.

1. Fossiliferous Mesozoic Rocks of New Guinea.

The Mesozoic stratigraphy and fauna of Netherlands New Guinea were summarized by Zwierzycki (1928, 1931) in his explanations to the geological maps of that territory, and reviewed by Hövig (in: Klein 1937, pt. 2). E. R. Stanley published data on the Mesozoic rocks of the Territory of New Guinea (1923, pp. 30-31) and of Papua (1923A, pp. 25-27). Certain statements on this subject in Stanley's publications require critical comments in order to define more clearly the available data.

The age of the *Alveolina*-limestone on Mt. Wilhelmina in Netherlands New Guinea, which was mentioned by Stanley, is Eocene (Zwierzycki 1928, p. 29). The fossils reported by Richarz from the Torricelli Mountains as Cretaceous (Cenomanian) are Miocene. This was recognized by Schubert and again emphasized by Zwierzycki (1928, p. 25). The "Cretaceous *Alveolina*-limestones" of the Finisterre Mountains on the North Coast of New Guinea are actually known to be Miocene, including Middle Miocene

at the genotype locality of *Flosculinella* Schubert (Kabarang River near Cape Rigny). Stanley was probably misled by references to "chalky" limestones. The *Globigerina*-limestones in the Njau plain on the border between Netherlands New Guinea and the Mandated Territory were reported by Schubert to contain Cretaceous foraminifera, but he pointed out that these fossils are possibly not *in situ*. The "cherts containing *Actinacis sumatrensis*" described by Gregory and Trench from pebbles collected in the Fly River have not been found by Osborne on his recent expedition to the Fly River headwaters. The range of the genus *Actinacis* is now known to extend into the Oligocene. The occurrence of fossiliferous Upper Cretaceous "at the head of Karova Creek, a few miles east-north-east of Kerema" has not been confirmed in the course of geological exploration carried out in this area on behalf of Australasian Petroleum Company. Some confusion concerning the locality of Stanley's specimen, which appears to have been lost subsequently, is suspected by the present writer. All fossils found by Everill "in about latitude 7° south on the Strickland River" came from pebbles and the inclusion of this area in the Mesozoic on the geological map of Papua is not justified. Recent work by Noakes revealed evidence for Neogene age of limestones in Northern New Britain for which Cretaceous age had been assumed on lithological grounds and on the evidence of a gastropod cast determined as "*Actaeonella*" (probably *Oliva* sp.).

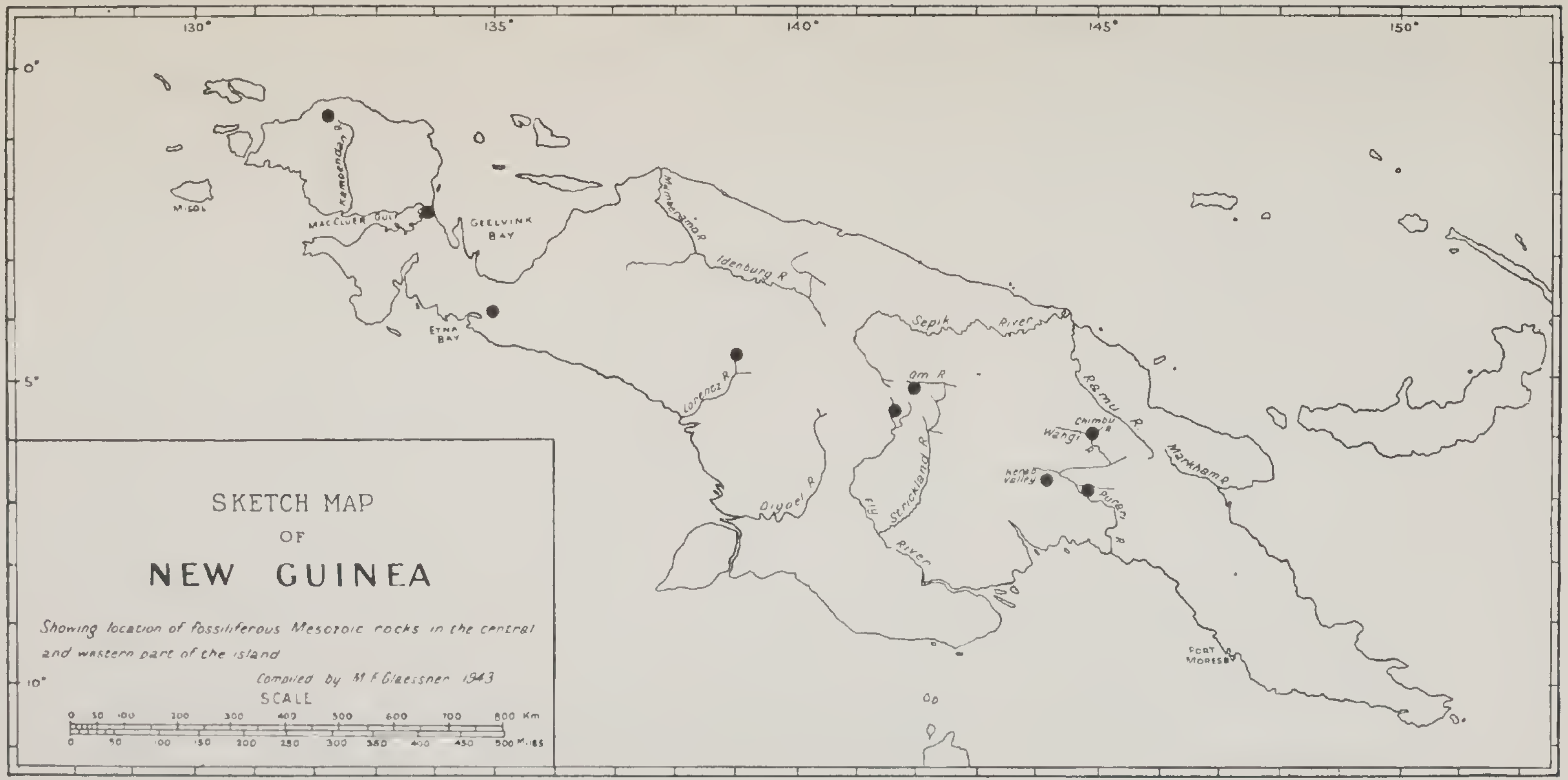
The known pre-Tertiary basement in a wide zone, including the northern coastal ranges of New Guinea, the Bismarck Archipelago, the Solomon Islands, New Hebrides, Fiji, and Tonga consists entirely of metamorphic or plutonic rocks.

The known occurrences of fossiliferous Mesozoic rocks in Papua and the Territory of New Guinea include the headwaters of the Fly, Strickland, and Sepik rivers, some of the country north of Mt. Murray (Kerabi Valley), and on the Middle Purari River, the Wahgi Valley (see map), and areas in the Owen Stanley Ranges.

2. The Age of Kuabgen Group.

The fauna with *Buchia malayomaorica* and *Belemnopsis gerardi*:—Abundant occurrence of *B. gerardi* and similar forms, together with large *Inoceramus* is a characteristic feature of Oxfordian strata in the eastern part of the Sunda archipelago. The middle part of the Jurassic sequence on the upper Fly river is therefore considered as Oxfordian. This agrees also with the distribution of *Buchia malayomaorica* at the numerous localities from which this species has been recorded. The same age is assigned to the *Buchia malayomaorica*-horizon of the Chimbu-Hagen area, about 2,700 feet above the base of the Mesozoic section described by Noakes. Pebbles with Oxfordian fossils are known from the Sepik river.

The stratigraphic range of the Kuabgen group:—The oldest Jurassic fossil found in the Fly River section is *Grammatodon virgatus,* which ranges from the *macrocephalus*-beds (Upper


SKETCH MAP
OF
NEW GUINEA
Showing location of fossiliferous Mesozoic rocks in the central and western part of the island
Compiled by M F Glaessner 1943
SCALE
0 50 100 200 300 400 500 600 700 800 Km
0 50 100 150 200 250 300 350 400 450 500 Miles
130°
135°
140°
145°
150°
0°
5°
10°
Misol
Kamoendan R
MacCluer Gulf
Geelvink Bay
Etna Bay
Mamberamo R
Idenburg R
Lorencz R
Digoel R
Sepik River
Om R
Strickland R
Fly River
Ramu R
Markham R
Chimbu R
Wangi R
Kerau Valley
Purari R
Port Moresby

Bathonian or Callovian) to the *cordatum*-zone (Upper Divesian-Lower Oxfordian). While this range gives no direct evidence of pre-Oxfordian age of the lower Kuabgen beds, the reported occurrence of this species in lower zones of the Upper Jurassic may be significant. Callovian fossils are well known as pebbles from the rivers of the Central Highlands of New Guinea, including the Strickland and Sepik. The species *Meleagrinella braamburiensis* and *Belemnopsis* cf. *indica* from a bed below the *Buchia*-horizon are forms which apparently did not range above the lower Oxfordian. This again agrees with the assumption that the base of the Oxfordian may be above the horizon of *Grammatodon virgatus*. Callovian age of this part of the Kuabgen group is therefore not unlikely. There is little evidence of Middle Jurassic (Bathonian-Bajocian) in this part of New Guinea. It is confined to a report of *Stephanoceras* from the Strickland pebbles.

The upper part of the Kuabgen group contains only *B. gerardi*. The age of this part of the section cannot be determined directly. The occurrence of uppermost Jurassic ammonites in the Sepik pebbles, to which a record of perisphinctids of "uppermost Jurassic or lowest Cretaceous" age determined by Reeside from beds outcropping in the Om River (Strickland headwaters) can now be added (see Osborne, 1944, p. 132) indicates the probability of Tithonian occurring in the area. No definite index fossils of uppermost Oxfordian or Kimmeridgian age have been recorded from the Indo-Pacific region.

The age of the Kuabgen group is therefore Upper Jurassic (possibly Callovian to Tithonian). Some Middle Jurassic may also be present in the vicinity of the Sepik-Strickland divide, in view of the recorded occurrence of *Stephanoceras*.

3. The Age of the Feing Group.

The age of the beds with *Parahibolites blanfordi*:—The lower part of the Feing group is characterized by the occurrence 500 feet above the top of the Jurassic of a belemnite known from the Lower Utatur group of Southern India (Upper Albian, *disparzone*). The character of the foraminiferal assemblage found in the lower Feing agrees with this age. The lowest part of the Cretaceous section is represented by sandstones from which a loose block containing fragments of belemnites, lamellibranchs, crinoids and echinoids (sample 209) is believed to be derived. As the belemnites could not be freed from the matrix, they remain, unfortunately, undetermined. It is not unlikely that the genus *Parahibolites* is represented among them. A more calcareous portion of this sample shows some slight resemblance with the molluscan bed of the Purari formation. This sandstone block contains pebbles some of which are evidently derived from

the Kuabgen group. A large pebble of black siliceous shale found loose at the same locality contains several specimens of a canaliculate belemnite.

The age of the beds with *Globotruncana* aff. *appenninica*:— The Lower Cretaceous lower part of the Feing group passes gradually upward into more argillaceous beds containing a rich assemblage of smaller foraminifera, including Upper Cretaceous forms such as single-keeled *Globotruncana* with inflated chambers (*appenninica*-type), *Bulimina reussi, Pleurostomella subnodosa,* together with other species known from Albian and Cenomanian (*Gyroidina nitida, Textularia washitensis, T. rioensis*). *Inoceramus* and *Turrilites* cf. *costatus* occur together with this assemblage which has a distinctly Cenomanian character.

4. The Age of the Purari Formation.

The Cretaceous beds in the hills north of the Purari River, about 120-136 miles up its course, were discovered by Sir William MacGregor in 1893-4.

Only a preliminary examination of the fossils collected at the same locality by Carey in 1940 has been carried out. The foraminiferal fauna indicates approximately Aptian to Albian age. The fauna of the molluscan bed contains elements related to species from the Tambo and Roma beds of eastern Australia (Upper Albian, Aptian), such as *Lingula* cf. *subovalis, Pseudavicula papyracea, Allaria* cf. *wilkinsoni, Tetrabelus macgregori,* but in the absence of ammonites it is impossible to assign it to definite zones. The Lower Cretaceous affinities of the fauna are strengthened by the occurrence of *Exogyra* cf. *couloni* and of further mollusca resembling Australian Lower Cretaceous forms which, however, have not yet been examined in detail. Most of the larger fossils appear to be derived from the upper 1,000 feet of the Cretaceous sequence which is transgressively overlain by Eocene. If this part of the Purari formation is assigned to the Aptian or Albian, the question arises whether the lower part of the sequence could represent earlier stages of the Lower Cretaceous. The uniform character of the foraminiferal assemblage throughout the sequence makes a very great age difference between the higher and lower beds unlikely.

5. Correlation of the Purari, Feing, and Kuabgen Strata.

The Purari formation cannot be considered as an equivalent of the entire Feing group. It is possible, however, that the upper part of the Purari formation corresponds to the lower part of the Feing. The conspicuous molluscan bed of the Purari formation has been reported from a number of widely scattered localities.

A typical specimen was obtained by Mr. Ethell, Patrol Officer, in the course of a patrol between Keuri (Sarugi) Valley and Lake Tebera, 20 miles west of the type locality on the Purari. One hundred and eighty miles further west, on the Strickland River, at the highest point reached by Everill in 1885, G. Barrow collected a pebble of a bluish-green calcareous sandstone with abundant mollusca. A similar rock was found in 1939 by the late L. Vial, then Assistant District Officer, in the Wahgi Valley west of Mingenda.

A detailed study of the Lower Tertiary and Mesozoic sequence in the lower Chimbu and Wahgi Valleys, which was carried out by L. C. Noakes in 1939, proved the existence of a series of sediments over 22,000 feet thick, "in which deposition extends conformably from about Jurassic to Eocene time." (This and the following quotations are taken from an unpublished report by L. C. Noakes, dated July, 1939.) Noakes divided this sequence, which consists predominantly of shales and mudstones, with some sandstones, into five "stages". The lower two and part of "Stage 3" are of interest in conjunction with the present investigation. A dark-red to chocolate shale with *Buchia malayomaorica* and *Inoceramus* was found in "Stage 1" about 2,700 feet above the base of the section. This "stage" consists mainly of slightly calcareous and siliceous shales.

The second "stage" is characterized by an abundance of tuffaceous sandstones most of which are laminated or interbedded with shale. A volcanic agglomerate was taken by Noakes as marking the base of this "stage". Most of the samples are unfossiliferous but fragments of *Ostrea*, a *Pseudavicula* and plant remains occur in the upper 1,500 feet (samples 28-36), suggesting a correlation with part of the Purari formation. "Stage 3" consists mainly of shales and mudstones. "The Mingenda ammonite horizon is considered to lie in the lower half of this stage" (Noakes). This bed, which is exposed on Mingenda Mission aerodrome, contains well-preserved ammonites and *Inoceramus* resembling those reported by E. R. Stanley (1923, p. 26) from the Kerabi Valley north of Mt. Murray. These appear to be approximately of middle Cenomanian age (Whitehouse 1926, p. 279. The writer was informed by Dr. Whitehouse that various published references to a fauna "from the Strickland River" are based on Stanley's specimens). The Mingenda bed and its equivalents in "Stage 3" contain also *Textularia washitensis*, a foraminiferal species known from the upper part of the Feing group.

The resulting correlations are shown in the following table:—

TABLE 1.—Correlation of Fossiliferous Mesozoic Strata in New Guinea.

		Fly River Area.	Strickland River Area.	Area between Strickland and Purari Rivers.	Wahgi River Area.	Purari River Area.
		(Transgressive Tertiary limestones)				(Transgressive Tertiary Limestones)
Cenomanian		Fcing Group (3,400 feet)		Kerabi beds (thickness and sequence unknown)	"Stage 3" (6,500 feet)	
Lower Cretaceous	Albian		"Fossiliferous Green-sand" (not known *in situ*)		"Stage 2" (6,200 feet)	Purari Formation (5,000 feet, base not known)
	Aptian					
	Neocomian				?	
Upper Jurassic		Kuabgen Group (4,000 feet)	Om river beds (thickness unknown)		"Stage 1" (4,500 feet)	

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Explanation of Plate.

Plate VI.

Fig. 1*a-b*.—*Grammatodon* (*Indogrammatodon*) *virgatus* (J. de C. Sowerby). Kuabgen Group (Upper Jurassic), Fly River Headwaters, Papua. (Coll. N. Osborne, sample 252.)

Figs. 2-4.—*Meleagrinella braamburiensis* (Phillips). Kuabgen Group (Upper Jurassic), Fly River Headwaters, Papua. (Coll. N. Osborne, sample 210.) Fig. 2—right valve, figs. 3, 4—left valves.

Figs. 5*a-b*, 6.—*Buchia malayomaorica* (Krumbeck). Kuabgen Group (Upper Jurassic, Oxfordian), Fly River Headwaters, Papua. (Coll. N. Osborne, sample 215.) Fig. 5*a*—right valve, external view; fig. 5*b*—same valve, internal view; fig. 6—left valve, internal view.

Fig. 7.—*Buchia malayomaorica* (Krumbeck). Wahgi Series. "Stage 1" (Upper Jurassic, Oxfordian), Lower Wahgi River, New Guinea. (Coll. N. Noakes, sample 57.) Left valve, external view.

Figs. 8, 9 *a-b*.—*Belemnopsis gerardi* (Oppel). Kuabgen Group (Upper Jurassic, Oxfordian), Fly River Headwaters, Papua. (Coll. N. Osborne, sample 215.)

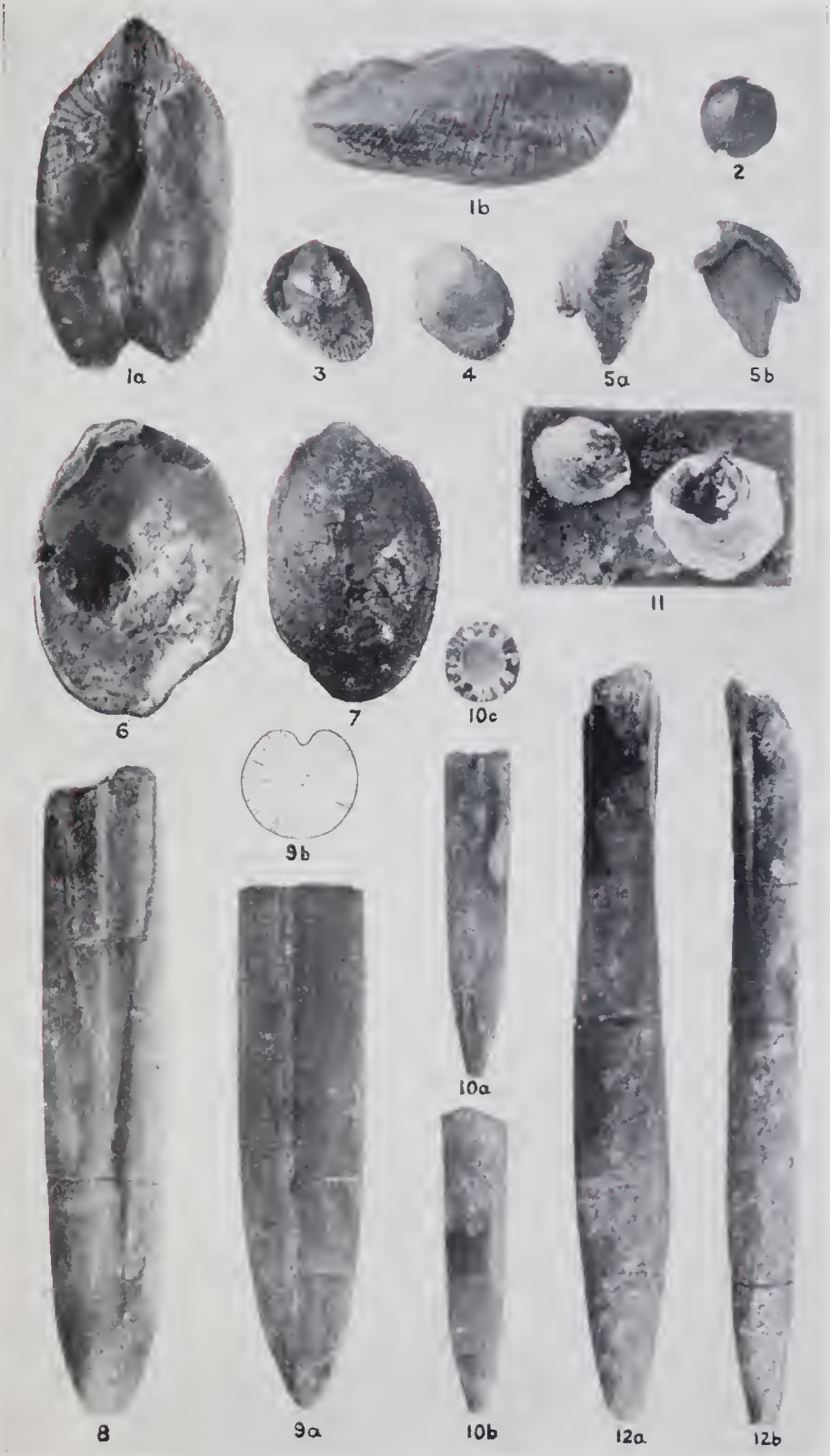
Figs. 10 *a-c*.—*Parahibolites blanfordi* (Spengler). Feing Group, lower part (Upper Albian). Fly River Headwaters, Papua. (Coll. N. Osborne, sample 210). Fig. 10*a*—ventral view, Fig. 10*b*—lateral view. Fig. 10*c*—alveolar view.

Fig. 11.—*Pseudavicula papyracea* (R. Etheridge, jun.). Purari Formation (Aptian-Albian), Wabo Creek, Purari River, Papua. (Coll. S. W. Carey, sample 22.)

Fig. 12*a-b*.—*Tetrabelus macgregori* n.sp. Holotype. Purari Formation (Aptian-Albian), Paw Creek, Purari River, Papua. Coll. S. W. Carey, sample 186, Melbourne University, Geol. Department Reg. No. 1876).

Photographs by Miss M. L. Johnson, Melb. Univ. Geol. Dept.

All figures approximately natural size.


1a
1b
2
3
4
5a
5b
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7
10c
11
9b
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9a
10a
10b
12a
12b